

Design of an Economically Efficient Feed-in Tariff

Presentation to the California Energy Commission

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Outline of Presentation

- Purpose of Feed-in Tariffs (FIT)
- Review of European FIT designs
- Economic limitations of current FIT designs
- Designing an economically efficient FIT
- Proposed auction-based capacity model
- Summary

Purpose of FITs

FITs are designed to encourage adoption of advanced renewable energy technologies

- Accelerate development of mid- to long-term renewable energy technologies
  - Encourage greater technological innovation
  - Accelerate cost reduction of technologies that are not currently economic at existing market prices
  - Provide financial stability and support for renewables developers
- Promote energy policy goals
  - Reduced fossil-fuel dependence
    - Decreased exposure to market volatility
  - Reductions in environmental degradation
    - Criteria pollutants regulated under the Clean Air Act
    - Reductions in greenhouse gases

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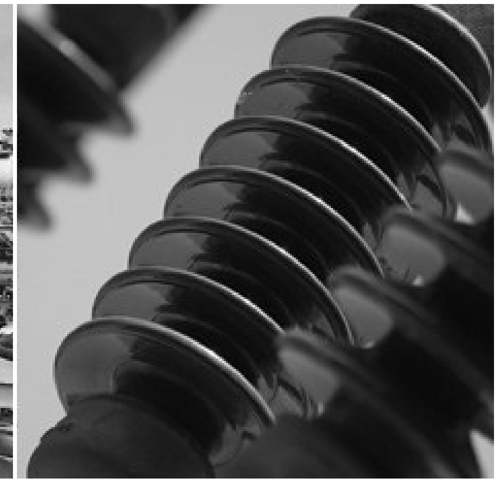

Review of European FIT designs

FITs common in European countries

- 17 EU countries use FITs
  - Austria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Latvia, Luxemburg, Netherlands, Portugal, Slovenia, and Spain
  - Other EU countries use quota-based policies, e.g, Belgium, Italy
    - UK use renewables obligation, similar to RPS
  - Tentative evidence suggests that FIT is more effective for achieving renewables targets than quota-based systems
- Germany, Denmark, and Spain considered model countries of FIT with significant results, both in installed capacity, and in renewables generation
  - Whether benefits greater than the costs is a far more difficult question
    - Significant solar capacity in Germany has led to high electric rates, which damage economic competitiveness

Case study 1: German FIT experience

- Electricity Feed-in Law (1991)
  - Utilities required to buy renewable energy at 90% of retail rate for electricity
    - Created a market for renewable energy
    - Designed to provide long-term financial stability to cover renewables costs
    - No time limit on utility purchases
  - Not tied to wholesale market cost of generation
  - As electricity prices fell after market liberalization in 1998, loss of financial viability of renewables developers
    - Led to changes in 2000
- Renewable Energy Law (2000)
  - Specific prices for different renewable technologies
    - Wind: fixed for first 5 years at 0.178 DM (US $0.11) per kWh and then decreases
    - PV: started with €0.52 for <100kW installations (US 2006$0.70) per kWh (€0.48/kWh for larger installations) and decreases by 5% annually
    - Payments extend for 20 years

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Case study 1: German FIT experience (cont.)

- Solar payments changed in 2004
  - PV installations on buildings up to €0.57/kWh
  - PV installations on ground up to €0.48/kWh

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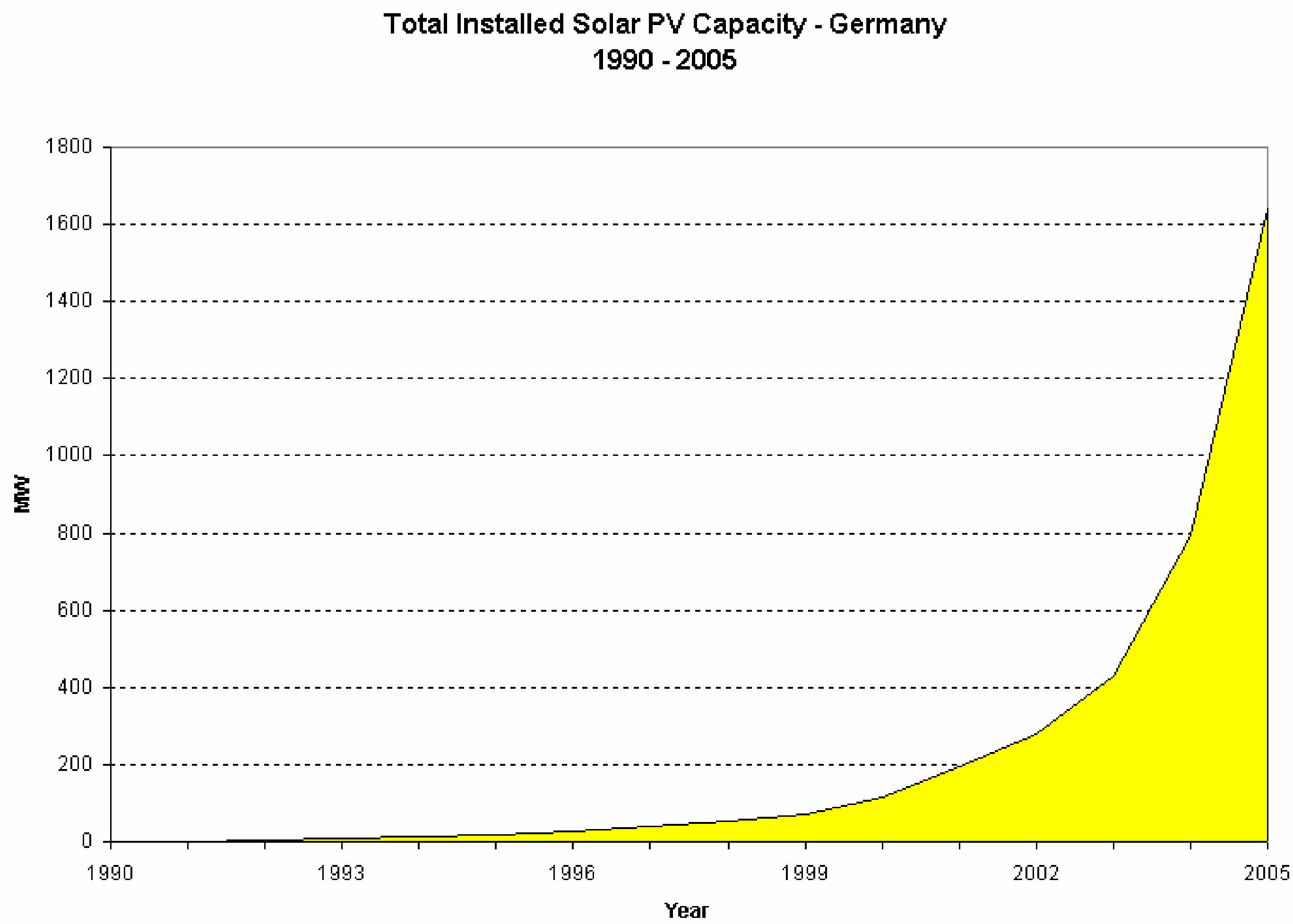
Germany – cumulative installed PV capacity: 1990-2005



Sources: 1990-1993: http://www.solarbuzz.com/FastFactsGermany.htm
1994-2005: BP Global, Statistical Review of World Energy 2006.

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Case study 2: Denmark FIT experience

- Started in late 1970s as a response to high oil prices
- Investment subsidy on renewable energy technologies (1979-1989)
  - Direct subsidy for a fixed percentage of capital costs
  - Declined from 30% to 10% of investment over that period
    - Varied inversely with energy tax on fossil fuel
- Production subsidy and other direct support mechanisms (1981-1992)
  - Utilities obligated to buy renewable energy at a fixed price between 70-85% of the retail price of electricity
- Domestic market support (1990-2000)
  - Government guaranteed long-term financing of large wind projects that used Danish-made turbines
- Electricity market liberalization/deregulation (2000 - current)
  - Gradual elimination of guaranteed prices and introduction of tradable green certificates (TGCs)
  - Danish wind energy market appears to be reaching saturation point
    - Wind provided over 16% of total energy generation in 2005
    - Only 12 MW on new capacity installed in 2006

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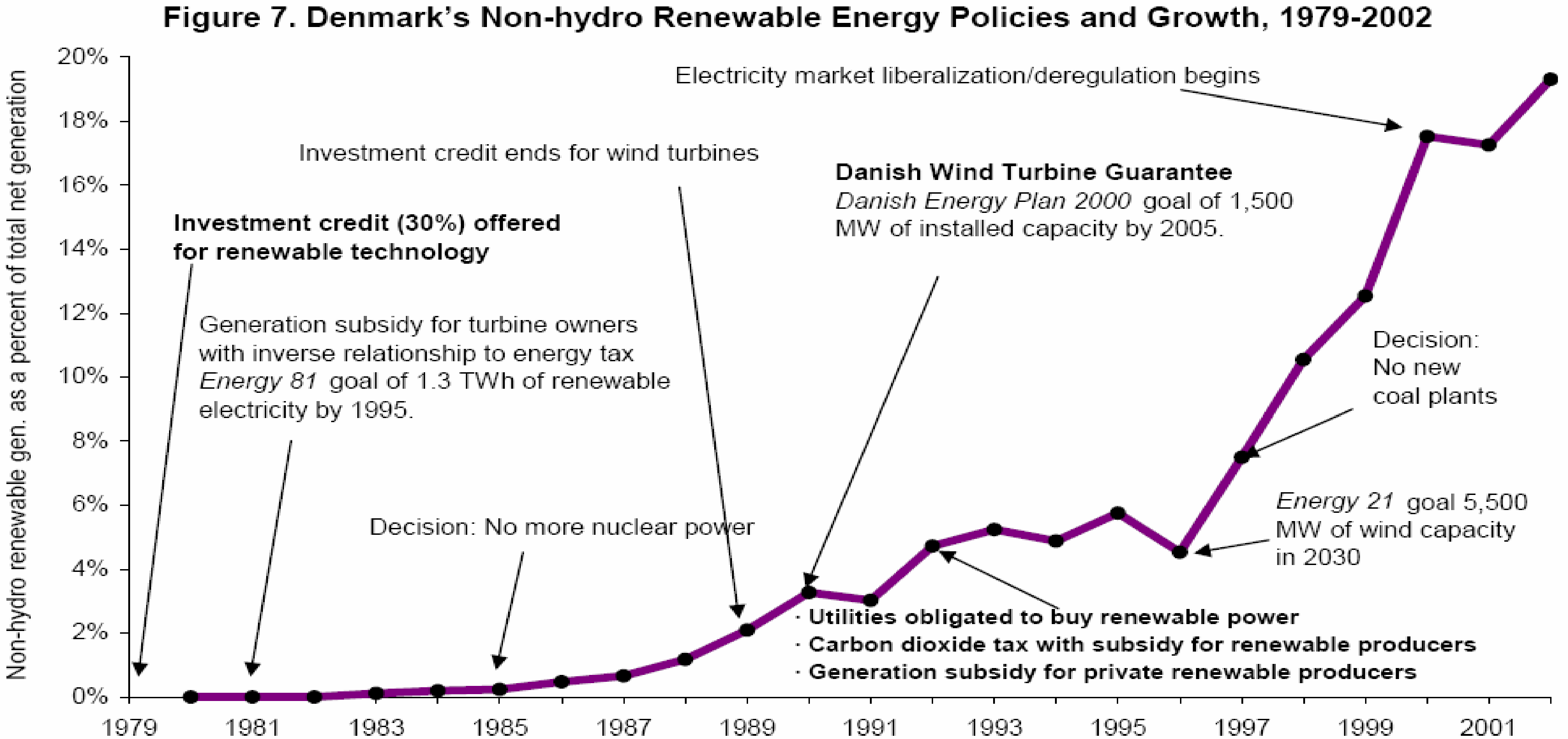
Denmark FIT Experience Chronology 1979-2002



TWh = Terawatthours
MW = Megawatts
Sources: Generation, Energy Information Administration, International Energy Annual; Policies, various sources compiled for and cited in this article by Office of Coal, Nuclear, Electric and Alternate Fuels, Energy Information Administration.

Source: Reprinted from DOE/EIA (2005), "Policies to Promote Non-hydro Renewable Energy in the United States and Selected European Countries," available at: http://www.eia.doe.gov/fuelrenewable.html

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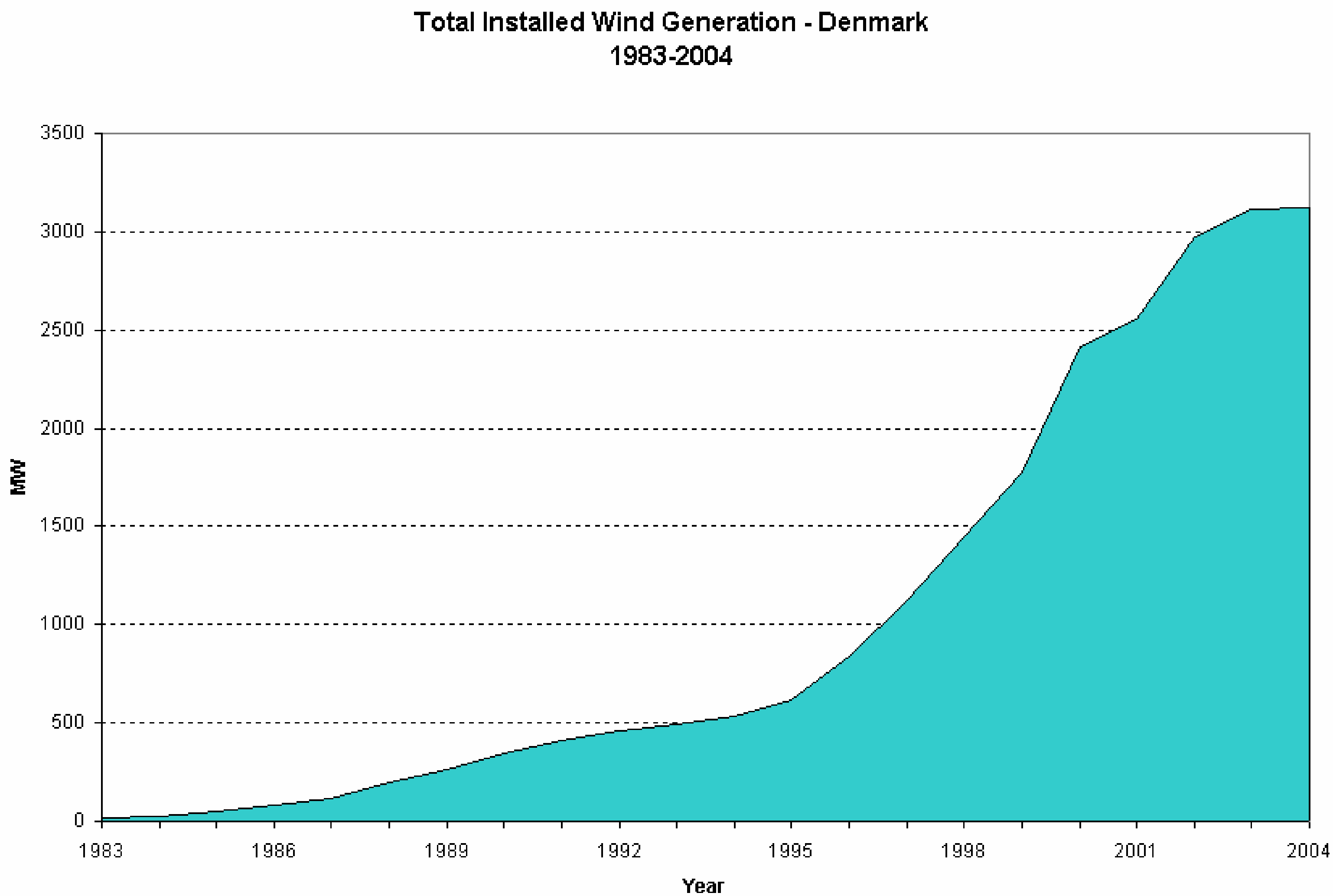
Denmark – cumulative installed wind capacity over time



Source: Danish Wind Energy Association.
http://www.talentfactory.dk/media(856,1033)/capacity_dk.xls

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Economic limitations of existing FIT designs

FITs are subsidies – which can be economically inefficient

- Public Utilities Regulatory Policy Act of 1978 (PURPA) was the first example of a FIT subsidy
  - Based on forecasts of "avoided costs" – not market-based
  - Regulators had to guess future market conditions over the next few decades
  - Forecasts typically wrong - sometimes by large margins
- PURPA encouraged development of inefficient technologies and so-called "PURPA machines"
  - Example: California SO4 contracts

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FITs are subsidies – which can be economically inefficient (cont.)

- Subsidies insulate market participants from rigors of the marketplace
  - Less efficient competitors continue operating – higher costs for consumers
  - Less investment by more efficient competitors – returns can decrease
  - Can slow down development of more advanced technologies
    - “Crowding out” by current renewable energy technologies

- Subsidies can often have perverse economic consequences
  - High prices can encourage rapid growth of near-term technologies and technologies that are too speculative
  - Technological setbacks can reduce future investment
    - Lower expected returns, greater risk, and higher cost financing

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Existing FITs still require regulators to forecast the future

- Regulators must establish price curves for each technology
- Regulators must forecast growth in technological improvement
  - Similar to “RPI – X” rate regulation, where “RPI” is an inflation factor and “X” is a productivity factor
    - Accurately predicting future productivity growth is probably impossible
    - In the same way, predicting rate of technological improvement is extremely difficult
  - “Endogeneity problem”– prices set by regulators can affect technological improvement rates
    - Too high a price, can actually reduce rate of technological improvement
    - Rates for individual technologies can affect other technologies

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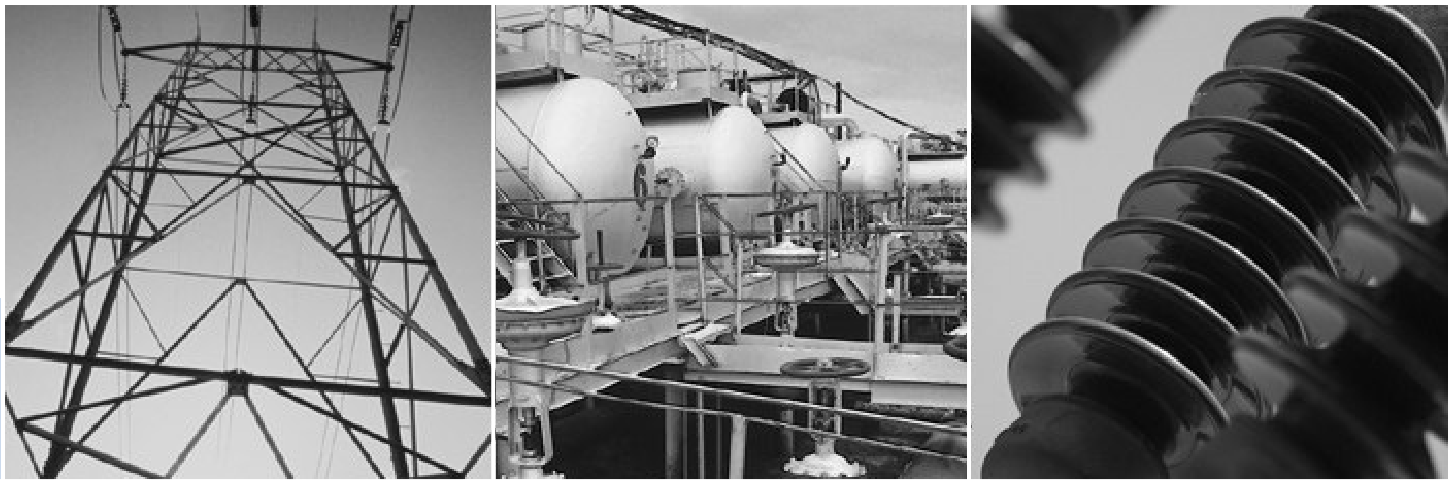

Designing an efficient FIT

FIT Design - leverage economic incentives and market information to promote efficient, least-cost policies

- Rely on market-based information
  - RET developers have better information than policy makers
    - Current available technologies
    - Expected technological progress
    - Trends in cost of generation
  - Elicit information from developers through the market itself
    - Minimize the use of long-term forecast values by policy makers
    - Minimize the use of cost of generation estimates to avoid over- or under-compensation
    - Minimize the use of estimates of rates of technological progress
  - Market-based approach reduces administrative burden and provides greater accuracy of information
    - "Win-win" for policymakers

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FIT Design – market design benefits and policy issues

- Efficient design allows policy makers to focus on objectives
  - Types of renewable technologies to receive FIT subsidy
    - Balance more mature renewable technologies versus incipient, but promising, RETs in the long term
  - Time horizons for FIT subsidies
    - Can be either a calendar time or some “trigger condition,” e,g., when renewab;e energy/capacity share reaches a certain percentage in total supply
    - Balance financial stability (known payments stream) and economic efficiency (economic operation)
- Policy makers must still be aware of caveats about subsidies and unrealistic renewable energy goals
  - Transmission interconnection issues (wind)
  - Retail electric rates and damage to economy
  - Reductions in technological progress

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FIT design – account for specific renewable energy technology characteristics

- Ensure <u>installation efficiency</u> and <u>operating efficiency</u>
  - Installation efficiency: installed capacity should embody the current technology frontier for a given renewable technology
    - Do not subsidize outdated technology or technology that is market-competitive
  - Operating efficiency: installed capacity should produce least-cost energy
- Two-part FIT provides a solution
  1. FIT capacity payment: determined through capacity market auction
     - Similar to forward capacity market, promotes installation efficiency and provides financial stability
  2. FIT energy payment: tied to actual power generation, dependent on spot market energy price
     - Competitive market energy price promotes operating efficiency

Why two-part FIT works

- Competition weeds out less efficient technologies as well as less efficient plants – let the market mechanism work!
  - Capacity payment – auction
    - Auctions have been widely and successfully used in the public domain, e.g. electromagnetic spectrum, offshore drilling rights, timber/logging rights, highway construction, treasury bills/notes/bonds, etc.
    - Auction selects more cost efficient RET producers without burdening policy makers to divine actual costs for each RET
    - California used an auction process in 1998-2002 for supplemental energy payments to renewables developers
      - Auction did not guarantee funds available in future – a critical difference to our proposal
  - Energy payment – competitive spot market
    - Encourages more energy production, but avoids paying distorted prices
    - The more energy produced when the market is tight (super-peak and peak periods), the higher is the payment – availability at peak time when needed
    - Competitive market rewards efficient RET producers, without requiring policy makers to monitor each producer's actions

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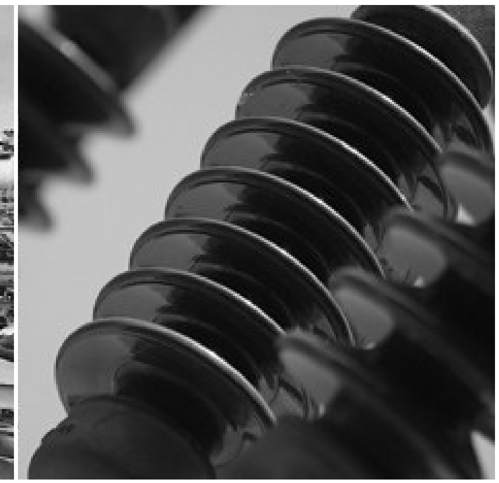
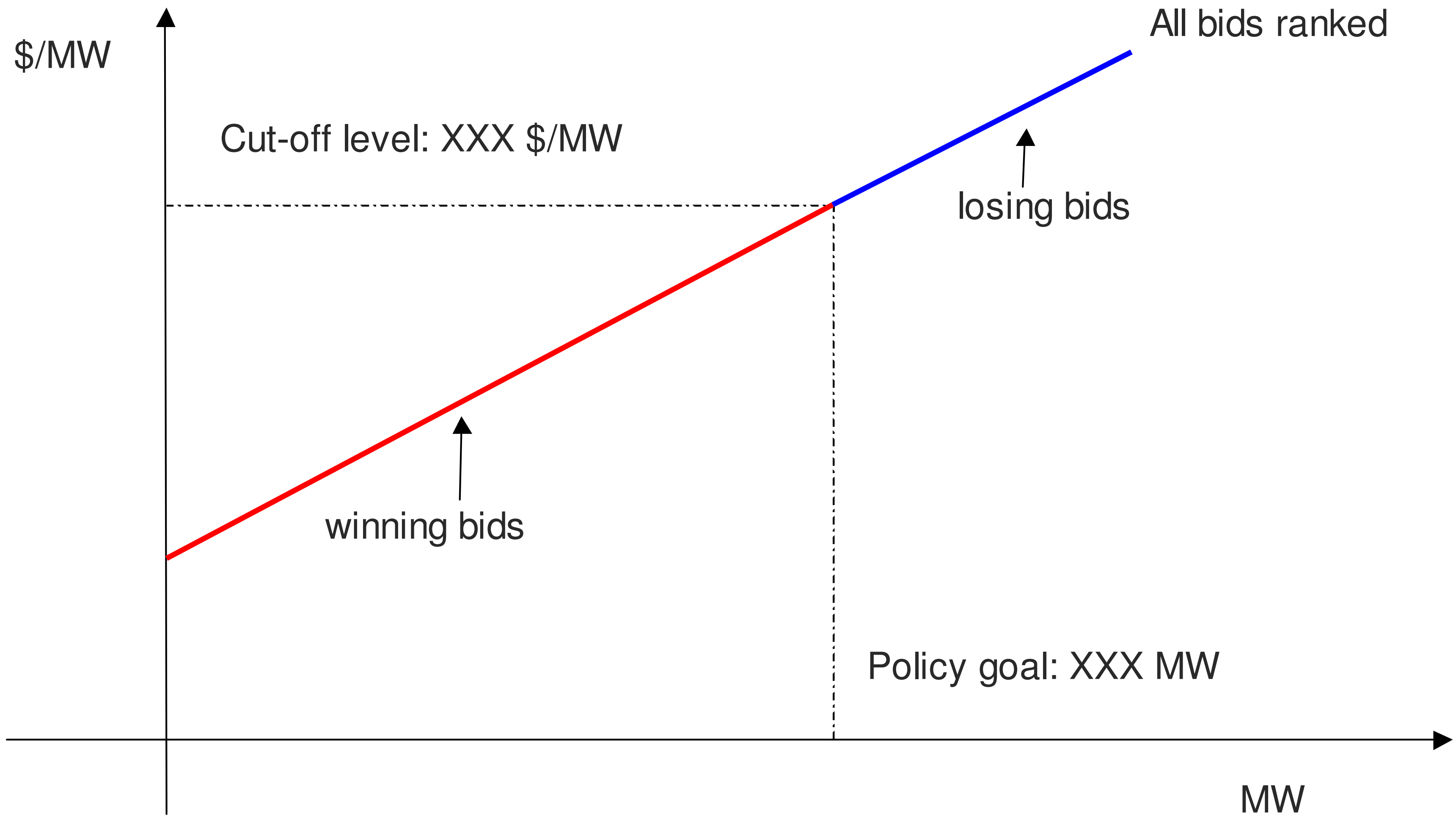


Proposed auction-based capacity model

FIT capacity auction design

- Similar to forward capacity market design in use by PJM, ISO-NE, and proposed for California ISO
  - Based on existing RET capacity, policy makers determine how much *incremental* capacity is needed to reach goals set for future years
    - Technology-specific goals established by policy makers
    - Example: 2008 Auction designed to solicit capacity on-line in 2010
- Interested parties participate in auction
  - Parties bid using selected auction format
    - Numerous alternative auction designs
  - All successful bidders are paid the market clearing price for capacity
  - Clearing price determined where bid capacity exactly meets policy goals for individual RETs
- Successful bidders penalized if they do not bring capacity on-line as agreed

An example: 2008 solar auction, 2010 online date



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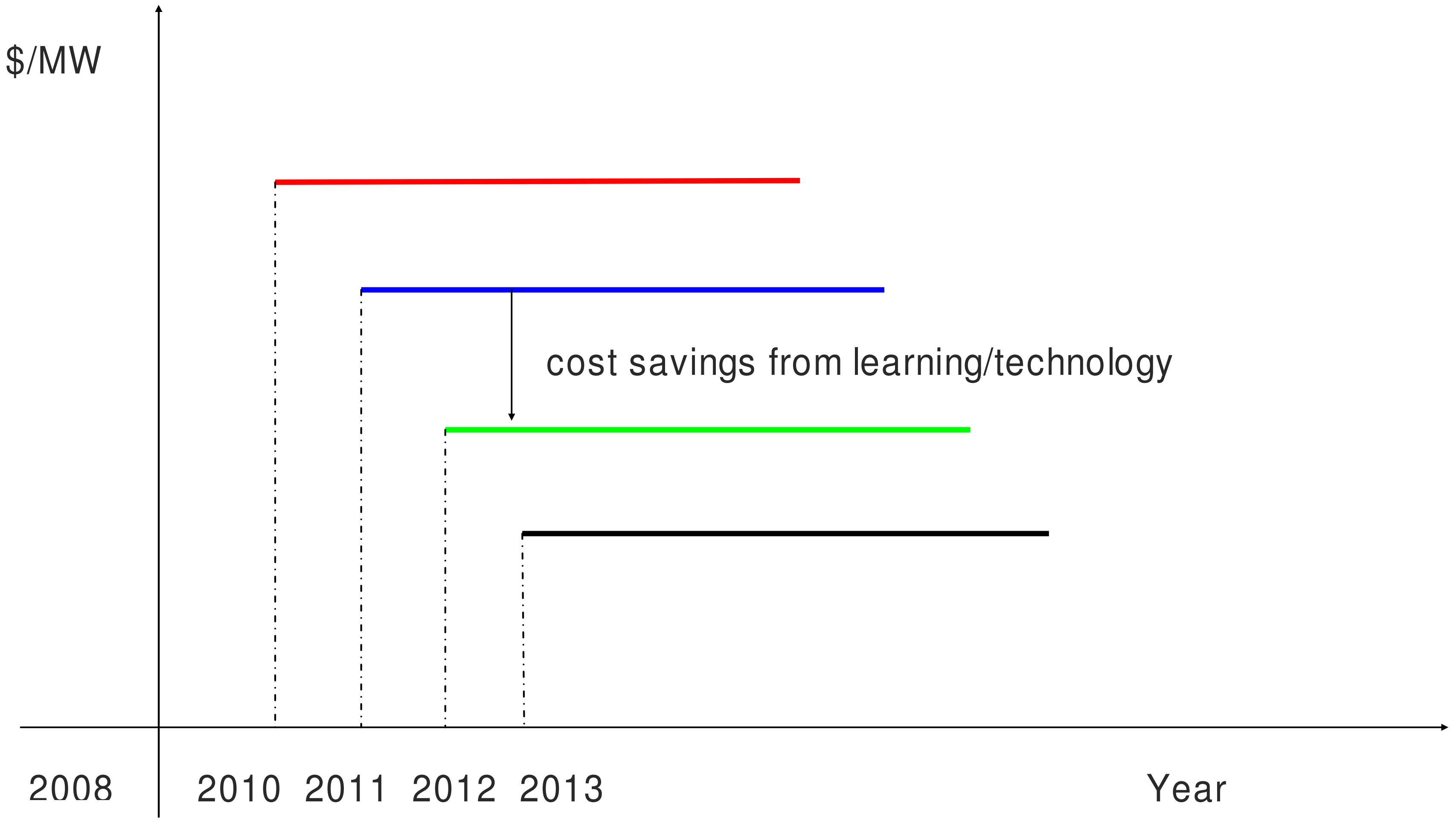
FIT capacity payment over time



Incentive mechanism

- Want capacity to produce as much energy as possible
  - Rather than FIT administrative energy price, RET providers sell energy into spot market, bilateral agreements, etc.
    - Choices are left to RET developers
  - Modify annual capacity payment in year T
    - Based on relative capacity factor (CF) of each technology of vintage (V) for each developer (N), relative to average capacity factor for technology of vintage

$$P_{V,N,T} = P_{V,T} \, x \left[\frac{CF_{V,N,T}}{CF_{V,T}} \right]$$

  - Similar to forward capacity market designs to encourage availability of installed capacity during high-demand hours
  - Energy price provides additional incentive to be generating power when most valuable

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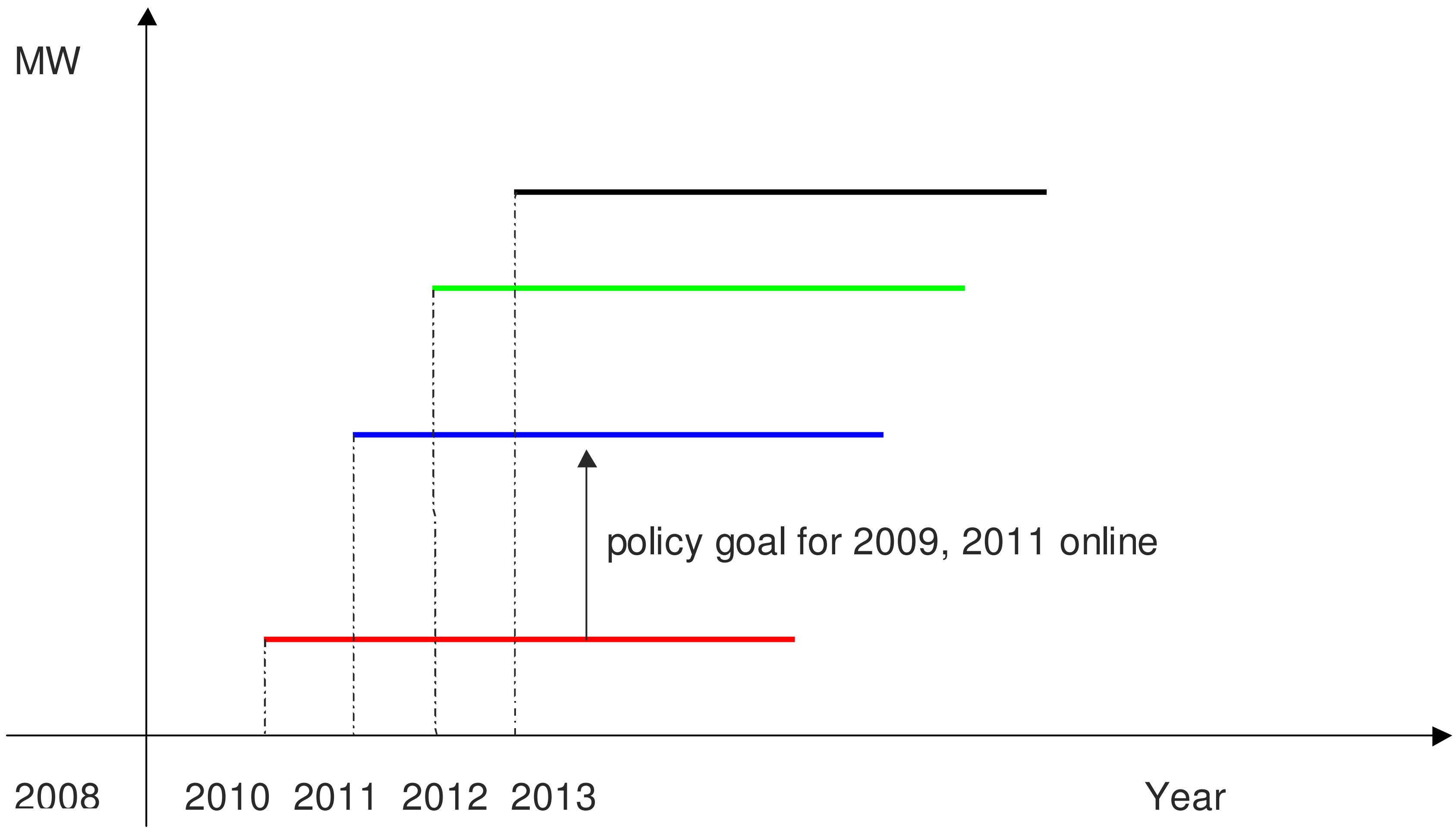
RET installed capacity over time



Additional Design Details

- Payments set to expire after selected years
- Example: 10-year payment streams
  - First auction in 2008, on-line date 2010
    - Payments for 2010 vintage through 2019
    - Payments for 2011 vintage through 2020
    - Etc.
- Date of final annual auction will depend on future market conditions
- Provides policy makers with flexibility
  - Can adjust incremental capacity MW goals annually, if necessary
    - Balance rate pressure if above-market prices
    - No need if RETs are at or below market prices (ex: fossil fuel prices rise significantly)

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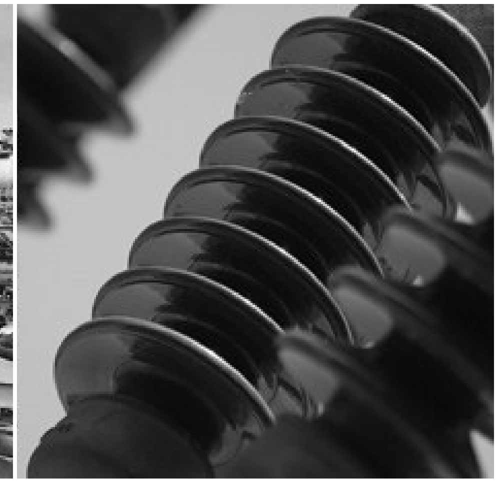

Summary and conclusions

Recommended design is superior to existing approaches

- Two-part design is economically efficient
  - Annual target of incremental RET capacity
  - Economically efficient approach to acquiring RETs
  - Promotes installation efficiency and operating efficiency
- Elicits market information without excessive administrative burden
  - Capacity payment determined through auction process
  - Energy payment tied to spot market price for electricity
  - RET technological progress rate taken into account over time
- Easy to implement and monitor
  - Provides policy makers with additional flexibility
    - Can adjust capacity goals over time, as needed

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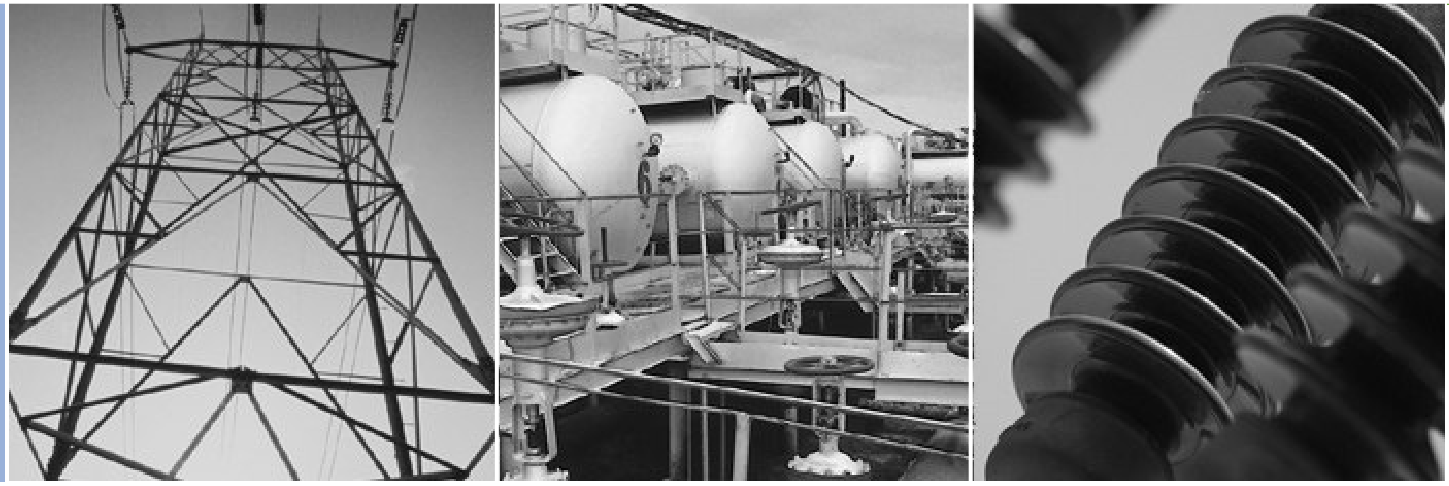

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